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ARTIFICIAL KEY TO THE SPECIES OF SNAKES AND LIZARDS WHICH ARE FOUND IN NORTH CAROLINA.

1. Eyelids moveable; external ear present; underparts covered with numerous scales; limbs present, except in Ophisaurus. *Lizards.* 2.
   Eyelids immovable; no external ears; underparts covered with broad band like plates; limbs absent. *Snakes.* 7.
2. Limbs absent. Length when adult about 2 ft. of which about two thirds are normally tail. **Glass or Joint Snake.* (*Ophisaurus ventralis*).
   Limbs present. Length when adult 1 ft. or less. 3.
3. Body very smooth and shiny. 4.
   Body not very smooth and shiny, scales at least somewhat rough. 5.
4. Length about 5 inches or less, unstriped. *Ground Lizard* (*Leiolepisma laterale*).
   Length over 5 inches or else with lengthwise stripes. Large adults often unstriped with reddish head. *Blue-*

*The tail as in all lizards is very easy to break off, and hence a glass snake with an injured tail growing afresh, may have the tail quite short.

tailed Lizard, "Red-headed Scorpion" (Eumeces quinquelineatus.)

5. Back crossbanded, or else throat and sides of belly dark blue. Scales very rough. *Fence Lizard (Sceloporus undulatus).*
   Back not crossbanded, throat not dark blue, scales not very rough. 6.

6. Back with lengthwise stripes *Sand Swift (Cnemidophorus sexlineatus).*
   Back unstriped. Color green, brown or blackish. *Green Lizard, "Chameleon" (Anolis carolinensis).*

7. A pit of hollow in the side of head between eye and nostril. Plates on underside of tail mostly not in pairs. Head much broader than the neck. *The Rattlesnakes and their kin. (Family Crotalidae).* 8.
   No pit on side of head between eye and nostril. Plates on under side of tail in pairs. Top of head covered with large plates. 11.

8. Tail with a rattle. Top of head covered with large plates. Size small. Rattle small. *Ground Rattlesnake (Sistrurus miliarius).*
   Tail with a rattle. Top of head covered with small scales. Size large, rattle large. 9.
   Tail without a rattle. Top of head covered with large plates. 10.

9. Markings on back in form of diamond-shaped blotches. *Diamond Rattlesnake (Crotalus adamanteus).*
   Markings on back in form of dark, ragged-edged cross bands, or sometimes when the animal is very dark, wholly absent. *Banded Rattlesnake (Crotalus horridus).*

10. Top of head blackish brown, colors darker. **Cottonmouth (Ancistrodon piscivorus).*

*The Cottonmouth is continually confused with the large water snakes of the genus Natrix, which are perfectly harmless.

Top of head reddish, colors paler. *Copperhead* (*Ancistron contortrix*).

11. Upper parts unmarked. 12.
Upperparts with evident markings. 22.

12. Upper parts green. 13.
Upper parts not green. 14.

13. †Scales keeled. *Southern Green Snake* (*Cyclophis aestivus*).
Scales smooth. *Northern Green Snake* (*Liopeltis vernalis*).

14. Color of upper parts black. 15.
Color of upper parts some shade of brown. 17.

15. Snout recurved and keeled. Scales keeled. *Black Adder* (*Heterodon platyrhinus var. niger*).
Snout as usual, not recurved nor keeled. 16.

16. Scales all smooth. Underparts slaty black except the throat which is white. *Black Snake* (*Bascanion constrictor*).
Middle rows of scales faintly keeled. Underparts blackish, except for about the front third, which is white. *Chicken Snake* (*Coluber obsoletus*).

17. Scales keeled. 18.
Scales smooth. 19.

18. Size small, under 1 ft. when adult. *Brown Snake* (*Haldea striatula*).
Size large. Coppery red below. *Copperbelly* (*Natrix f. erythrogastra*).

19. Size large. (Young crossbanded, a foot long when hatched.) *Coachwhip* (*Bascanion flagellum*).
Size small, under one foot when adult. 20.

† The scales of a snake are either perfectly smooth or else with a little ridge down the middle, in the latter case they are said to be keeled.

20. Under parts reddish. *Ground Snake* (*Carphophiops amoenus*).
Under parts whitish or yellowish. 21.

21. Top of head darker than back. Color of back reddish brown. *Brown-headed Snake* (*Rhadinaea flavilata*).
Top of head same color as back. Color of upper parts grayish brown. **Valerias Snake* (*Virginia valeriae*).

22. Markings confined to red and black blotches on the sides. Under parts red. Size large, scales smooth. *Horn Snake* (*Farancia abacura*).
Markings on upper parts confined to a light or dark cross band on neck. 23.
Back striped or spotted or both. 24.

23. Under parts white, crossband on neck black. *Crowned Tantilla* (*Tantilla coronata*).
Under parts reddish, crossband on neck white. *Brown Snake* (*Haldea striatula*), *some young specimens.*
Under parts yellow, spotted with black, crossband on neck, yellow. *Ringnecked Snake* (*Diadophis punctatus*).

24. Body striped lengthwise. 25.
Body not striped lengthwise. 31.

25. Scales keeled. 26.
Scales, or at least most of the lower rows, smooth. 30.

26. Under parts with dark stripes. *Willow Snake* (*Natrix leberis*).
Under parts not striped. 27.

27. Size small, under 1 ft. when adult. No side stripes but only one down the middle of back. 28.
Size larger, adults over two feet in length. Side stripes usually present. 29.

28. Under parts red. Three pale spots on nape. *Redbellied Snake* (*Storeria occipitomaculata*).

*Valerias Snake usually has small blackish dots on back, but these are not very conspicuous.

Under parts whitish. Not three pale spots on nape. *DeKays Snake* (*Storeria dekayi*).

29. Side stripes on third and fourth rows of scales, counting from belly plates; no square black spots between stripes of side and that on back. *Slim Garter Snake* (*Eutaenia sirtalis*).
Side stripes on second and third rows of scales. Square black spots between stripes. *Garter Snake* (*Eutaenia sirtalis*).

30. Three red stripes on a darker ground. Underparts red, spotted with black. *Hoop Snake* (*Abastor erythrogrammus*).
Four dark stripes on a lighter ground. Underparts yellowish. *Striped Chicken Snake* (*Coluber quadrivittatus*).

31. Body above with crossbands of red, black, and white (or yellow). 32.
Body not colored as above. 34.

32. Every alternate crossbar yellow. *Coral Adder* (*Elaps fulvius*).
Every alternate crossbar black. 33.

33. Snout narrow, under parts white. *Red Snake* (*Cemophora coccinea*).
Snout rounded, under parts with black markings. *Red King Snake* (*Ophibolus doliatus coccineus*).

34. Scales all smooth. 33.
Scales keeled. 42.

35. Black with narrow white crossbars forking on the sides. *King Snake* (*Ophibolus getulus*).
Not as above. 36.

36. Underparts with squarish black spots. 37.
Underparts not with squarish black spots. 38.

37. Head large, broader than the neck. †Anal plate divided. *Spotted Racer. Rat Snake* (*Coluber guttatus*).
Head small, not broader than neck. Anal plate undivided. *Milk Snake* (*Ophibolus doliatus triangulus*).

38. Head large, broader than neck. Anal plate divided. 39.
Head small, not broader than neck. Anal undivided. *Brown King Snake* (*Ophibolus rhombomaculatus*).

39. ‡Scales in 25 or 27 rows. 40.
Scales in 19 rows. 41.

40. Underparts yellowish. *Striped Chicken Snake, young.*
Underparts slaty black behind, whitish in front. *Chicken Snake, young.*

41. §Upper lip plates 7 on each side. *Black Snake, young.*
Upper lip plates 8 on each side. *Coachwhip, young.*

42. Snout recurved and keeled. 43.
Snout not recurved and keeled. 44.

43. Small plate just behind snout plate with several small scales round it. Snout more strongly recurved and keeled. *Hognosed Snake* (*Heterodon simus*).
Small plate just behind snout plate without any small scales round it. Snout less strongly keeled and recurved. *Spreading Adder* (*H. platyrhinus*).

44. Anal plate undivided. Ground color whitish with dark spots on back. *Bull Snake* (*Pityophis melanoleucus*).
Anal plate divided. 45.

†Anal plate is the plate immediately in front of the vent, which in most of our forms is divided longitudinally into two pieces, but in some it is undivided.

‡Rows of scales are counted diagonally beginning with the row just above the belly plates and are usually uneven in number.

§The upper labials or lip plates are the plates along the edge of the upper lips, excluding the plate at tip of snout.

45. Only the middle rows of scales keeled, size small. **Chicken Snake, young.*
All rows of scales strongly keeled. 46.

46. Spots on back forming crossbars with no alternating spots on sides. *Southern Water Snake* (*Natrix fasciata fasciata*).
Spots on back forming crossbars on front part of body, and on hinder part alternating with spots on the sides. *Common Water Snake* (*Natrix fasciata Sipedon*).
Spots on back alternating with spots on sides from head to tail. *Pied Water Snake* (*Natrix taxispilota*).

NOTES ON THE SPECIES INCLUDED IN THE KEY.

The following species are poisonous: The three species of Rattlesnake (Ground, Banded, and Diamond Rattlesnakes), the Copperhead, and the Cottonmouth, and lastly the Coral Adder, which last belongs to the same group of snakes as the deadly cobra of India. The following harmless snakes are often confused with poisonous species: the Spreading Adder with the Copperhead; the harmless water snakes with the cottonmouth, both forms being indiscriminately known as water moccasins; and the red snake and red king snake with the coral adder.

A few of the species listed have not yet been recorded from North Carolina, these are the coral adder, northern green snake, coachwhip, and milk snake, and we have only one unsatisfactory record of the bull snake.

Of the species included in the key, the following have not yet been taken in this state outside of the lower austral life zone, whose northern boundary in this state appears to be approximately a line drawn from Norfolk through Raleigh, and thence to Charlotte:

*The Southern Chicken Snake (Coluber obsoletus confinis) may possibly occur, in which case the keys for the young of the Chicken Snake would apply to this also. I do not know how the young of the two forms would be distinguished.

Glass Snake, at Raleigh, Garner, Southport, Beaufort.

Green Lizard, at Southport, Wilmington, Beaufort, Lake Ellis, Tryon, and Lumberton.

Hoop Snake, at Newberne, Kinston, Wilmington, Lake Ellis.

Horn Snake, at Newberne, Wilmington, Lake Ellis.

Brown headed Snake at Fort Macon.

Hognosed Snake in Wake Co., at Goldsboro and Lake Ellis.

Spotted Racer at Raleigh, Lake Ellis and Washington.

Striped Chicken Snake, at Newberne and Cape Hatteras.

Red King Snake, at Raleigh.

Red Snake at Raleigh.

Pied Water Snake at Kinston, Avoca, Newberne and Lake Ellis.

Southern Water Snake at Newberne, Wilmington, and Lake Ellis.

Crowned Tantilla at Raleigh.

Cottonmouth at Newberne, Wilmington, Lake Ellis, Cape Hatteras, Beaufort, Washington, and Raleigh.

Ground Rattlesnake, at Wilmington, and Beaufort.

Diamond Rattlesnake at Havelock below Newberne.

Records of the Coral Adder, Coachwhip, Milk Snake, Northern Green Snake, and Bull Snake are very much desired as also records of any other species of snakes and lizards, particularly those confined to the lower austral zone.

Of the four species listed as possibly occurring in the state, the Coral Adder and Coachwhip are confined to the lower austral zone, and should be looked for in the southeastern portion of the state, while the Milk Snake is most apt to be found in the northwest corner. The Northern Green Snake is apt to occur anywhere in the state but is not likely to be common anywhere, and the Bull Snake, of which we have a doubtful record from Wake Co. is liable to occur in the pine woods of the region near the coast.

The other species of snakes and lizards probably occur throughout the entire state, except in portions of the moun-

tain region, but our actual records are few and scattered.

Persons having specimens of any reptile that they are not well acquainted with, would do well to communicate with the Curator of the State Museum at Raleigh, or with myself.

C. S. BRIMLEY,
Newberne Ave., cor. Tarboro St.,
Raleigh, N. C.

(Information is also desired concerning the occurrence of the alligator in the state and also as to the occurrence of the species of soft shelled turtles in the Mississippi drainage as well as in the southeast of the state, the two different parts in which they may possibly occur.)

THE SALAMANDERS OF NORTH CAROLINA

C. S. BRIMLEY

Salamanders are animals which are commonly confused with lizards and which mainly resemble them in external appearance. Their true affinities, in spite of the possession of limbs, are however with the fishes, with which group they and the other amphibians are sometimes combined under the name of Icthyopsida.

They differ externally from from all our lizards in the possession of a moist skin without scales, while all our lizards have a dry scaly skin. The skin in salamanders and other amphibians (frogs and toads) is always moist, and used to some extent (wholly in many species) as an organ of respiration.

The forms which occur or are liable to occur in this state may be recognized by the following key.

KEY TO THE SALAMANDERS OCCURING OR LIABLE TO OCCUR IN NORTH CAROLINA

1. Adults with with external gills, 2.
   Adults without external gills, 5.
2. Hind limbs absent, 3.
   Hind limbs present. Toes 4 on both hind and forefeet, 4.
3. Toes 4. Size large. *Great Siren* (*Siren lacertina*).
   Toes 3. Size small. *Little Siren* (*Pseudobranchus striatus*).
4. Brown with darker spots. Water Dog (*Necturus maculatus*).

Pale unspotted. *Southern Water Dog* (*Necturus punctatus*).

5. Adults with a rounded opening on each side of neck, 6.
Adults without a rounded opening on each side of neck, 7.

6. Body eel-shaped, with rudimentary limbs. Toes 2 or 3 each on both fore and hind feet. *Ditch Eel* (*Amphiuma means*).
Body stout, salamander shaped. Toes 4 on fore, 5 on hind feet. *Hellbender* (*Cryptobranchus alleghaniensis*).

7. Tongue mushroom shaped, i. e. a circular disk on a central stalk, 8.
Tongue not attached by a central stalk only, 15.

8. Toes on hind feet 4. Size very small, yellowish brown. *Dwarf Salamander* (*Manculus quadridigitatus*).
Toes on hind feet 5. (Genus Spelerpes), 9.

9. *Costal grooves, 13 or 14. 10.
Costal grooves 15 to 17. 13.

10. Tail about as long as rest of body. Yellow with a dark line along each side of back. Underparts unmarked. *Striped Salamander* (*S. bilineatus*).
Tail 1 1–2 to 2 times as long as body. 11.

11. Color vermilion red, with many brown spots. Tail spotted, not barred. *Spotted tailed Trition* (*S. maculicaudus*).
Color yellow. 12.

12. Underparts marbled with black. Back with a black stripe down middle and another on each side. *Holbrook's Triton* (*S. guttolineatus*).
Underparts unmarked. Back and sides with irregular black spots. *Long-tailed Salamander* (*S. longicauda*).

*Costal grooves are grooves on the sides indicating where the ribs are.

13. *Upper jaw bearing on its margin, immediately below each nostril, a prominent tubercule. Color light chocolate brown, spotted with brown. Underparts unmarked. *Daniel's Salamander* (*S. danielsi*).
Upper jaw bearing no such tubercle. 14.

14. Color red of varying shades spotted above or below with black or both. *Red Triton* (*S. ruber*).
Color yellowish or purplish brown above, irregularly blotched with gray. *Purple Salamander* (*S. porphyriticus*).

15. Head with three longitudinal grooves. Underparts yellow or red below with black dots. 16.
Head without longitudinal grooves. 17.

16. Each side with a row of red spots, each spot surrounded by a black ring. *American Newt* (*Diemyctylus viridescens*).
Each side with a series of black bordered red lines, replacing the black ringed spots. *Wilmington Newt* (*D. v. vittatus*).

17. Salamanders with rather long toes on all four feet, the outer and inner ones well developed. Tail compressed. (Genus Ambystoma). 18.
Salamanders with shorter toes, the outer or inner toes or both usually reduced in size or rudimentary. Tail not much compressed. 26.

18. Costal grooves 10. Form short and stout. Color blackish brown with gray, lichen like markings. *Mole Salamander* (*A. talpoideum*).
Costal grooves more than 10. 19.

19. Costal grooves usually 11. 20.
Costal grooves 14. 23.

*Similar tubercles occur more or less frequently in Manculus quadridigitaus, Sp. bilineatus, Sp. guttolineatus and regularly in Sp. maculicauda.

20. Bluish black with gray or white blotches or crossbars on the upper parts of head, body and tail, usually about 12 or 14 in all. Underparts unmarked. *Marbled Salamander* (*A. opacum*).
Not as above. 21.

21. Black with a series of large round yellow spots down each side of back. A strong dorsal groove. *Spotted Salamander* (*A. punctatum*).
Lead colored with one or two series of small yellow spots along sides. No dorsal groove, size small. *Smaller Spotted Salamander* (*A. conspersum*).
Not as above. 22.

22. Dark brown, yellowish below. No markings. *Sope's Salamander* (*A. Sopeanum*).
Olive brown, yellowish below. Limbs banded, tail spotted. A few ill-defined yellowish spots above. *Two colored Salamander* (*A. bicolor*).

23. Markings grayish or whitish. 24.
Markings brown or yellow. 25.

24. Olive brown or blackish with pale or bluish spots, these sometimes absent. *Jefferson's Salamander* (*A. jeffersonianum*).
Black with a narrow gray line between each pair of costal folds, these either crossing the back undivided to meet their fellows from the opposite side or forking to meet a similiar fork from the other side. Underparts thickly speckled with gray. *Banded Salamander* (*A. cingulatus*).

25. Tail very long, much longer than head and body. *Ohio Salamander* (*A. xiphias*).
Tail about as long as head and body. Color varying from uniform brown to yellow, but usually spotted. *Tiger Salamander* (*A. tigrinum*).

26. Toes on hind feet 4. Underparts with dots like ink spots. *Scaly Salamander* (*Hemidactylium scutatum*).
Toes on hind feet 5. 27.

27. Head with enlarged pores, which give it a pitted appearance. Underparts usually with black dots. Sides with dark longitudinal stripes. *Margined Salamander* (*Stereochilus marginatus*).
Not as above. 28.

28. Tail compressed and finned at least for the apical two thirds. 29.
Tail rounded. 32.

29. Color wholly black above and below. *Black Triton* (*Desmognathus nigra*).
Color not all black. 30.

30. Snout very flat, broad and depressed. Yellowish buff, thickly marked above with confluent black blotches. Underparts unmarked. *Moore's Triton* (*Leurognathus marmoratus*).
Snout more or less arched. 31.

31. Skin of head granulated. Underparts usually more or less uniform slate color. Size rather large. *Mountain Triton* (*Desmognathus quadrimaculatus*).
Skin of head not granulated. Underparts pale. *Brown Triton* (*Desmognathus fusca*).

32. Color brownish yellow, often spotted. *Yellow Salamander* (*Desmognathus ochrophea*).*
Color blackish or plumbeous. (Genus Plethodon.) 33.

33. Color lead-colored with a chestnut red dorsal band, size small. *Redbacked Salamander* (*P. erythronotus*).
Color uniform lead color. *Plumbeous Salamander P. c. cinereus*).
Color black with various markings. 34.

34. Black with red legs. *Sherman Salamander* (*P. Shermani*).

*All the species of the the genus Desmognathus have a peculiar physiognomy which is very characteristic, but not easy to describe.

Black with an orange yellow stripe on sides of head and neck. *Jordan Salamander* (*P. jordani*).
Black with bluish white blotches and specks, occasionaly unspotted. *Slimy Salamander* (*P. glutinosus*).
Black with yellowish green blotches of irregular form on back and sides. *Bronzy Salamander* (*P. aeneus*).

Of the above species the following have not yet been taken in the state: Little Siren, Spotted-tailed Triton, Long-tailed Salamander, Smaller spotted Salamander, Cope's Salamander Two-colored Salamander, Banded Salamander, Ohio Salamander, Scaly Salamander, Jordan Salamander, Bronze Salamander. Most of these however may possibly occur, and some of them are almost certain to be secured with more careful and complete collecting.

The species known to occur in the State have been collected in the following localities:

Great Siren. Craven Co., New Hanover Co.
Water Dog. Wake.
Southern Water Dog. New Hanover.
Ditch Eel. Wake, Edgecombe, Dare, Bertie and Craven.
Hellbender. Yancey.
Dwarf Salamander. Wake, Lenoir.
Striped Salamander. Wake, Buncombe, Yancey, Mitchell and Forsyth.
Holbrook's Triton. Wake, Buncombe, Forsyth, and valley of French Broad.
Daniel's Salamander. Yancey.
Red Triton. Wake, Buncombe, Mitchell, Carteret, Yancey, Burke, Orange, Wayne, Forsyth and Henderson.
Purple Salamander. Mitchell.
American Newt. Wake, Henderson, Lenoir.
Wilmington Newt. New Hanover.
Mole Salamander. Valley of French Broad.
Marbled Salamander. Wake, Edgecombe, Guilford, Columbus, Forsyth, Lenoir.
Spotted Salamander. Wake.

Tiger Salamander. Moore.
Jefferson Salamander. Mitchell.
Redbacked Salamander. Mitchell, Pitt (same localities for Plumbeous S).
Margined Salamander. Craven.
Black Triton. Mitchell.
Moore's Salamander. Grandfather Mt.
Mountain Salamander. Yancey, Mitchell, Henderson.
Brown Triton. Wake, Craven, Forsyth, Lenoir.
Yellow Triton. Yancey, Mitchell.
Sherman Salamander. Nantahala Mt.
Slimy Salamander. Whole State.

A KEY TO THE SPECIES OF FROGS AND TOADS LIABLE TO OCCUR IN NORTH CAROLINA

C. S. BRIMLEY

1. Upper jaw without any teeth. 2.
   Upper jaw with teeth. 5.

2. Skin smooth. Size small. Snout pointed. No paratoid glands (just behind ear). Hind feet not webbed. *Toothless Frog* (*Engystoma carolinense*).
   Skin warty. Paratoids large. Hind feet little webbed. Head with bony ridges above. Toads. 3.

3. Size small, length of head and body one inch. Skin very rough. Bony ridges turning inward almost at right angles just back of the eyes. *Dwarf Toad* (*Bufo quercicus*).
   Size larger, adults about 3 or 4 inches long. Skin not so rough. Bony ridges on top of head not turning abruptly inward back of eyes. 4.

4. Bony ridges ending in a knob behind. *Southern Toad* (*B. lentiginosus*).
   Bony ridges not ending in a knob behind. *Common Toad* (*B. l. americanus*).

5. Paratoids present. Hind feet webbed. Heel with a flat, sharp edged spur. *Solitary Spadefoot Scaphiopus holbrooki*).
   Paratoids absent. No sharp edged spur on heel. 6.

6. Fingers and toes dilated at their tips, this dilation forming a viscous disk. Tree frogs. 7.
   Fingers and toes not much dilated at tips. 13.

7. Back with a dark x-shaped mark, size small. *Peeper* (*Hyla pickeringi*).
Back marked or not, but if marked, the markings do not form an x-shaped mark. 8.

8. Back of thigh not marked with yellow spots or variegations. 9.
Back of thigh with yellow spots or variegations. 11.

9. A yellow band on upper lip and sides of body, sharply defined above and below. Back with minute yellowish spots. *Carolina Tree Frog* (*Hyla cinerea*).
Yellow or white band on sides not sharply defined above and below. 10.

10. Size large, feet edged with yellow. *Georgia Tree Frog* (*H. gratiosa*).
Size small, feet not edged with yellow. *Squirrel Tree Frog* (*H. squirella*).

11. Size large, skin of back rough. A light spot on upper jaw just below eye. *Common Tree Frog* (*H. versicolor*).
No light spot below eye. 12.

12. A plum colored line along sides of body with yellow spots below it. *Anderson's Tree Frog* (*H. andersoni*).
No yellow spots on sides. *Pine woods Tree Frog* (*H. femoralis*).

13. Feet unwebbed, size small. (Genus Chorophilus). 14.
Feet more or less webbed. 15.

14. Skin of upper surface granulated. *Chorus Frog* (*C. nigritus and subspecies*).
Skin of upper surface smooth, a dark patch on ear. *Smooth Chorus Frog* (*C. occidentalis*).

15. Size small. Skin above warty. A dark triangle between eyes. *Cricket Frog* (*Acris gryllus*).
Size larger. Skin above smooth. 16.

16. A ridge of raised skin along each side of back. 17.
No narrow ridge of raised skin along side of back. 19.

17. A black ear patch. *Wood Frog* (*Rana sylvatica*).
No black ear patch. 18
18. Fold of skin down each side of back white. Back with large dark spots. *Leopard Frog* (*Rana pipiens*).
Fold of skin down each side of back the same color as back. Back with a few small dark spots or none. *Spring Frog* (*Rana clamata*).
19. Back with large dark spots in two rows. Size medium. *Pickerel Frog* (*Rana palustris*).
Back with irregular dark spots or none. Size large. *Bullfrog* (*Rana catesbiana*).
Sides with two light brown longitudinal bands. *Cope's Frog* (*Rana virgatipes*).

Of the species included in the key the following have not yet to my knowledge been recorded from from North Carolina: Anderson's Tree Frog, Georgia Tree Frog, Smooth Chorus Frog, and Southern Toad.

The other species have been taken in the following localities:

Toothless Frog. Wake, Johnston and Wayne Co's.

Dwarf Toad. Lenoir and Carteret.

Common Toad. Forsyth, Wake, Jackson, Craven, Lenoir and Wayne.

Solitary Spadefoot. Wake.

Peeper. Wake, Mitchell, Wayne, Johnston, Guilford.

Carolina Tree Frog. Lenoir and Dare.

Squirrel Tree Frog. Dare, Craven, Brunswick.

Pine woods Tree Frog. Craven and New Hanover.

Common Tree Frog. Wake, Wayne, Forsyth Pitt.

Chorus Frog. Guilford and Wake.

Cricket Frog. Wake, Craven, Wayne, Forsyth, Guilford.

Wood Frog. Lenoir.

Pickerel Frog. Wake, Mitchell, Lenoir.

Leopard Frog. Wake, Craven, Edgecombe, Dare.

Spring Frog. Craven, Wake, Forsyth, Guilford, Mitchell.

Bullfrog. Wake, Craven, Edgecombe.

Cope's Frog. Craven.

These keys (to snakes and lizards, salamanders, and to toads and frogs) have been prepared with the idea of giving intelligent persons without special knowledge on the subject an opportunity of identifying our native forms of these groups. The keys must not be expected to be infallible though I have endeavored to make them as accurate as possible.

ON SOME PHENOMENA OF COALESCENCE AND REGENERATION IN SPONGES[1]

BY H. V. WILSON

I

In a recent communication I described some degenerative and regenerative phenomena in sponges and pointed out that a knowledge of these powers made it possible for us to grow sponges in a new way. The gist of the matter is that silicious sponges when kept in confinement under proper conditions degenerate in such a manner that while the bulk of the sponge dies, the cells in certain regions become aggregated to form lumps of undifferentiated tissue. Such lumps or plasmodial masses, which may be exceedingly abundant, are often of a rounded shape resembling gemmules, more especially the simpler gemmules of marine sponges (Chalina, *e. g.*), and were shown to possess in at least one form (Stylotella) full regenerative power. When isolated they grow and differentiate, producing perfect sponges. I described moreover a simple method by which plasmodial masses of the same appearance could be directly produced (in Microciona). The sponge was kept in aquarium until the degenerative process had begun. It was then teased with needles so as to liberate cells and cell agglomerates. These were brought together with the result that they fused and formed masses similar in appearance to those produced in this species when the sponge remains quietly in aquarium. At the time I was forced to

[1]Reprinted from JOURNAL OF EXPERIMENTAL ZOÖLOGY, VOL. V, NO. 2., and published with the permission of Hon. Geo. M. Bowers, U. S. Commissioner of Fisheries.

leave it an open question whether the masses of teased tissue were able to regenerate the sponge body.

During the past summer's work at the Beaufort Laboratory[2] I again took up this question and am now in a position to state that the dissociated cells of silicious sponges after removal from the body will combine to form syncytial masses that have power to differentiate into new sponges. In Microciona, the form especially worked on, nothing is easier than to obtain by this method hundreds of young sponges with well developed canal system and flagellated chambers. How hardy sponges produced in this artificial way are and how perfectly they will differentiate the characteristic skeleton, are questions that must be left for more prolonged experimentation.

Taking up the matter where it had been left at the end of the preceding summer, I soon found that it was not necessary to allow the sponge to pass into a degenerative state, but that the fresh and normal sponge could be used from which to obtain the teased out cells. Again in order to get the cells in quantity and yet as free as possible from bits of the parent skeleton, I devised a substitute for the teasing method. The method adopted is rough but effective.

Let me briefly describe the facts for Microciona. This species (M. prolifera Verr.) in the younger state is incrusting. As it grows older it throws up lobes and this may go so far that the habitus becomes bushy. The skeletal framework consists of strong horny fibers with embedded spicules. Lobes of the sponge are cut into small pieces with scissors and then strained through fine bolting cloth such as is used for tow nets. A square piece of cloth is folded like a bag around the bits of sponge and is immersed in a saucer of filtered sea-water. While the bag is kept closed with the fingers of one hand it is squeezed between the arms of a small pair of forceps. The pressure and the elastic recoil of the

[2] I am indebted to the director of the station, Mr. H. D. Aller, for his kindly aid in supplying all facilities needed in the course of my investigation.

skeleton break up the living tissue of the sponge into its constituent cells, and these pass out through the pores of the bolting cloth into the surrounding water. The cells, which pass out in such quantity as to present the appearance of red clouds, quickly settle down over the bottom of the saucer like a fine sediment. Enough tissue is squeezed out to cover the bottom well. The cells display amœboid activities and attach to the substratum. Moreover they begin at once to fuse with one another. After allowing time for the cells to settle and attach, the water is poured off and fresh sea-water added. The tissue is freed by currents of the pipette from the bottom and is collected in the center of the saucer. Fusion between the individual cells has by this time gone on to such an extent that the tissue now exists in the shape of minute balls or cell conglomerates of a more or less rounded shape looking to the eye much like small invertebrate eggs. Microscopic examination shows that between these little masses free cells also exist, but the masses are constantly incorporating such cells. The tissue in this shape is easily handled. It may be sucked up to fill a pipette and then strewn over cover glasses, slides, bolting cloth, watch glasses, etc. The cell conglomerates which are true syncytial masses throw out pseudopodia all over the surface and neighboring conglomerates fuse together to form larger masses, some rounded, some irregular. The details of later behavior vary, being largely dependent on the amount of tissue which is deposited in a spot, and on the strength of attachment between the mass of tissue and the substratum.

Decidedly the best results are obtained when the tissue has been strewn rather sparsely on slides and covers. The syncytial masses at first compact and more or less rounded, flatten out, becoming incrusting. They continue to fuse with one another and thus the whole cover glass may come to be occupied by a single incrustation, or there may be in the end several such. If the cover glass is examined at intervals, it will be found that differentiation is gradually taking place. The dense homogeneous syncytial mass first develops at

the surface a thin membrane with underlying connective tissue (collenchyma). Flagellated chambers make their appearance in great abundance. Canals appear as isolated spaces which come to connect with one another. Short oscular tubes with terminal oscula develop as vertical projections from the flat incrustation. If the incrustation be of any size it produces several such tubes. The currents from the oscula are easily observed, and if the cover glass be mounted in an inverted position on a slide the movements of the flagella of the collar cells may be watched with a high power (Zeiss 2 mm.). This degree of differentiation is attained in the course of six or seven days when the preparations are kept in laboratory aquaria (dishes in which the water is changed answer about as well as running aquaria). Differentiation goes on more rapidly when the preparation is hung in the open harbor in a live-box (a slide preparation inclosed in a coarse wire cage is convenient). Sponges reared in this way have been kept for a couple of weeks. The currents of water passing through them are certainly active and the sponges appear to be healthy. In such a sponge spicules are present, but some of these have unquestionably been carried over from the parent body along with the squeezed out cells.

The old question of individuality may receive a word here. Microciona is one of that large class of monaxonid sponges which lack definite shape and in which the number of oscula is correlated simply with the size of the mass. While we may look on such a mass from the phylogenetic standpoint as a corm, we speak of it as an individual. Yet it is an individual of which with the stroke of a knife we can make two. Or conversely it is an individual which may be made to fuse with another, the two forming one. To such a mass the ordinary idea of the individual is not applicable. It is only a mass large or small having the characteristic organs and tissues of the species but in which the shape of the whole and the number of the organs are indefinite. As with the adult so with the lumps of regenerative tissue. They have no definiteness of shape or size, and their structure is only definite

in so far as the histological character of the syncytial mass is fixed for the species. A tiny lump may metamorphose into a sponge, or may first fuse with many such lumps, the aggregate also producing but a single sponge although a larger one. In a word we are not dealing with embryonic bodies of complicated organization but with a reproductive or regenerative tissue which we may start on its upward path of differentiation in almost any desired quantity. A striking illustration of this nature of the material is afforded by the following experiment. The tissue in the shape of tiny lumps was poured out in such wise that it formed continuous sheets about one millimeter thick. Such sheets were then cut into pieces, each about one cubic millimeter. These were hung in bolting cloth bags in an outside live-box. Some of the pieces in spite of such rough handling metamorphosed into functional sponges.

Even where the embryonic bodies of sponges have a fixed structure and size, as in the case of the ciliated larva, the potential nature as displayed in later development, is not fixed in the matter of individuality. Such a body may form a single individual or may fuse with some of its fellows to form a larger individual differing from the one-larva sponge only in size. It is then in spite of its definiteness of shape and size, essentially like a lump of regenerative tissue in that whether it develops into a whole sponge or a part of a sponge depends not on its own structure but on whether it is given a good opportunity of fusing with a similar mass. A parallel case to the coalescence of larvæ is afforded by the gemmules of fresh water sponges. Mr. M. E. Henriksen in a manuscript account submitted to me a year ago, describes the fusion of gemmules to form a single sponge.

In the preceding description I have passed over the question as to the precise nature of the cells which combine to form the masses of regenerative tissue. On this point as on the histological details in general I hope to have more to say later. Nevertheless the phenomena are so simple that observation of the living tissue reveals much, probably indeed all

that is of fundamental importance. If a fairly dense drop of the squeezed out tissue be mounted at once and examined with a high power (Zeiss 2 mm., comp. oc. 6), the preparation is seen to consist of fluid (sea-water) with a few spicules and myriads of separate cells. The cells fall into three classes.

1 The most conspicuous and abundant are spheroidal, reddish, densely granular, and about 8μ in diameter. These cells which can be nothing but the unspecialized, amœboid cells of the mesenchyme (amœbocytes or archæocytes), put out hyaline pseudopodia that are sometimes elongated, more often rounded and blunt.

2 There is also a great abundance of partially transformed collar cells, each consisting of an elongated body with slender flagellum. The cell is without the collar, the latter doubtless having been retracted. In the freshly prepared tissue the flagella are vibratile, the cells moving about. Soon however the flagellum ceases to vibrate.

3. The third class is not homogeneous. In it I include more or less spheroidal cells ranging from the size of the granular cells down to much smaller ones. Many of these are completely hyaline, while others consist of hyaline protoplasm containing one or a few granules.

Fusion of the granular cells begins immediately and in a few minutes time most of them have united to form small conglomerate masses which at the surface display both blunt and elongated pseudopodia. These masses soon begin to incorporate the neighboring collar and hyaline cells. One sees collar cells sticking fast by the end of the long flagellum to the conglomerate mass. Other collar cells are attached to the mass by short flagella. Still again only the body of the collar cell projects from the mass while there is no sign of flagellum. Similarly spheroidal hyaline cells of many sizes are found in various stages of fusion with the granular conglomerate. In such a preparation the space under the cover glass is soon occupied by innumerable masses or balls of the kind just described, between which continue to lie abundant free cells, some collar cells, others hyaline. Practically all

the granular cells go to make up the balls. The play of pseudopodia at the periphery of such balls, which results in the incorporation of free cells and in the fusion of balls to form larger masses, is easily watched. Along with such a cover glass preparation it is convenient to have some of the squeezed-out tissue in a watch glass of sea-water. In the watch glass preparation it is instructive to watch with a two-thirds or one-half objective the fusion of the cell conglomerates to form masses like those strewn on covers, slides, etc.

These observations on the early steps in the formation of the masses of regenerative tissue make it plain that such masses are composed chiefly of the spheroidal, granular cells (amœbocytes or archæocytes), but that nevertheless other cells, collar cells and more or less hyaline cells also enter into their composition. I may recall the fact that in the formation of regenerative masses in a degenerating sponge,[3] the evidence from sections, which is the only evidence available in the case, points to the conclusion that the collar cells help to form the syncytial tissue of the masses. The question of interest lying at the heart of this matter may be so formulated: can particles of the Microciona protoplasm differentiate into functional collar cells and, when the occasion arises, change back into unspecialized masses capable of combining with other masses of unspecialized protoplasm to form a regenerative body? The facts to which I have just alluded support this idea, and indicate that the immediate problem is one worth pursuing farther as a good case of temporary differentiation of protoplasm in the metazoa analogous to the temporary specialization of the cell individual which occurs in such colonial protazoa as Protospongia.[4]

As far as the amœbocytes are concerned it is certain that they have great regenerative power. Weltner in a recent

[3] A new method by which sponges may be artificially reared, Science, n. s., vol. xxv, no. 649, 1907.

[4] Metschnikoff, Embryologische Studien an Medusen, p. 147, 1886.

paper[5] has emphasized the importance of these unspecialized cells in the process of growth and regeneration. His conclusions which refer directly to fresh water sponges, are that in a growing sponge, in a sponge regenerating new organs after its winter period of simplification, and in the regeneration of a sponge from a cutting, the amœbocytes are the all-powerful elements in that they give rise to all the new tissues formed. He further alludes to the fact that such reproductive bodies as the gemmules of fresh water sponges and the buds of Tethya (according to Maas) are only groups of amœbocytes; further that the gemmules of Tedania and Esperella described by Wilson as developing into ciliated larvæ, and the similar bodies found by Ijima in hexactinellids, are such groups. I may add that the presence of such groups of unspecialized cells in the hexactinellids has recently been confirmed by the master in sponge-morphology, F. E. Schulze, who recognizes the probability of their reproductive nature and gives them a new name, that of *sorites*.[6] It is clear then that in many sponges reproductive bodies are formed by the association of unspecialized amœboid cells. But there is nothing in this fact which precludes the possibility that the groups of amœbocytes are in part recruited from transformed collar cells and other tissue cells, such as pinacocytes (flat cells of canal walls), that have undergone regressive differentiation into an unspecialized amœboid condition.

Cells analogous to the amœbocytes of sponges are found elsewhere in the metazoa, *e. g.*, in the ascidians.[7] It would be interesting to know what capacity, if any, for development they have, when freed from the parent (bud) and collected together in sea-water.

[5] Spongilliden-studien V. Zur Biologie von Ephydatia fluviatilis und die Bedeutung der Amœbocyten für die Spongilliden. Archiv für Naturgeschichte, 73 Jahrg., 1 Bd., 2 Heft, 1907.

[6] Wissensch. Ergebn. d. Deutsch. Tiefsee-Exp. 1898-99. Hexactinellida, pp. 213-15. Jena, 1904.

[7] Comp. Hjort's and Lefevre's papers on budding in ascidians.

II

I shall here briefly record some experiments which gave only negative results but which under circumstances admitting of a wider choice of species, ought to yield returns of value. These experiments were based on the assumption that if the dissociated cells of a species will recombine to form a regenerative mass and eventually a new sponge, the dissociated cells of two different species may be made to combine and thus form a composite mass bearing potentially the two sets of species-characteristics. It is clear that such an organism would be analogous to one produced by an association of the blastomeres of the two species. Pending the successful carrying out of this experiment, it would be idle to discuss further the nature of the hypothetical dual organism.

In my own experiments three sponges were used: Microciona, Lissodendoryx and Stylotella. The three are all monactinellids but Microciona is the only one in which the skeleton includes any considerable amount of horny substance. Dissociated cells of Microciona and Lissodendoryx were mixed, and again dissociated cells of Microciona were mixed with those of Stylotella. In each case the experiment was performed at two different times, and a considerable number of admixtures, in watch glasses and on cover glasses, was made. The preparations were examined at short intervals with the microscope. The cells of these three species are colored very differently, and are therefore easily distinguished, at least as soon as fusion sets in and little masses of cells begin to be formed. In all the experiments the cells and cell-masses of a species combined and not the cells of different species. Thus in the admixture of Microciona and Lissodendoryx, Microciona regenerative masses and Lissodendoryx regenerative masses were produced. Similarly when Microciona and Stylotella cells were mixed, the resultant masses were pure, some Microciona, some Stylotella. The Microciona masses in these experiments were hardy. They continued to develop and in some preparations metamorphosed. The cell masses of the other two species while they reached a considerable size were

not hardy, most dying soon although some began the process of metamorphosis.

These three species are so unlike that there was little ground in the beginning for the expectation that coalescence would take place. Possibly as in the cases where fusion of egg and sperm of different species is induced through some alteration in the physiological state of protoplasm, so the generative cells and cell masses of different species may be made to combine under abnormal conditions. The more promising task is however to find allied species and subspecies, the regenerative tissue of which will combine under natural conditions. Such forms, I take it, should be sought among the horny sponges and the monactinellids with abundant horny matter.

III

The tendency to fuse so vigorously displayed by the cells and cell masses of regenerative tissue led me to examine into the power that larvæ have to fuse with one another and the capacity for development in the resultant mass. Delage and others have remarked on the not infrequent occurrence of fusion between sponge larvæ. Delage[8] says that he has often observed two or several larvæ unite to form a single sponge "which has from the start several cloacas."

I find that this power to fuse displayed by the larvæ is one that is easy to control. Fusion between the larvæ will readily take place if they are brought in contact at the critical time when the ciliated epithelium is being replaced by the permanent flat epithelium. At this time they will fuse in twos or threes or in larger number up to and over one hundred. The smaller composite masses composed of as many as five or six larvæ metamorphose into sponges. The larger masses composed of many larvæ did not metamorphose in my experiments but experience with the regenerative tissue suggests that such masses would metamorphose if certain mechanical difficulties due to the great size of the mass were

[8] Embryongénie des Eponges. Arch. de Zool. Exp. et Gén., p. 400, 1892.

removed. Possibly this might be accomplished by cutting a flattened sheet composed of some hundred larvæ (such as I have produced) into pieces and inducing the pieces to metamorphose separately.

I may now describe some of the details in this process of larva-fusion. In a species of Lissodendoryx used the larva is of the following character. It has the usual ovoidal shape with a protuberant non-ciliated pole. The anterior pole is somewhat truncated and is sparsely ciliated. The rest of the body bears the usual thick covering of cilia. As seen with reflected light the bulk of the body is dead white, the posterior pole deep blue, and the anterior pole bluish. This coloration is not absolutely fixed for the species, but the larvæ used in my coalescence experiments were all of this character. Within twenty-four hours after liberation the ciliated larvæ are creeping (remaining in contact with the bottom as they swim) over the bottom of the dish. Some are now put in deep round watch glasses and with pipette and needle coaxed together into a clump. Fusion soon begins and on the next day plenty of composite larvæ are present. The larvæ fuse endwise, for the most part in pairs. The compound larva so produced owing to its weight has a very feeble locomotory power. Using pairs that are nearly motionless, larvæ may be brought together (coaxed with needle) and arranged in a desired position on a cover glass for instance. In successful cases fusion results before the separate masses move apart. In this way, selecting an instance, I have added to one arm of a quadruple mass a pair of larvæ, and to the opposite arm two pairs,

For the purpose of bringing about the fusion of many larvæ the following simple method is convenient. Suppose that we have the larvæ in a paraffine-coated dish, and they are in a late "creeping" stage. Small excavations, 2–3 mm. deep and 4–5 mm. wide, are now made in the paraffine, and with the pipette the larvæ are driven into the holes. They lie here in numbers up to and over one hundred, crowded together and heaped upon one another. Fusion begins soon

and the larvæ are gradually converted into a flattened cake. The larger cakes thus made measured four by three millimeters. The body of such a cake is a continuous flattened mass in which there is no indication of the component larvæ, but the rounded ends of the larvæ that have last fused with the general mass remain for a time distinguishable. Owing to their blue coloration the ends of the larvæ may be recognized in these and the other compound masses even after the outline of the larva has been completely lost.

As already stated the smaller compound masses metamorphose without difficulty. The coalesced larvæ may be made to attach to cover glasses, slides, etc. Larger masses composed of about twenty larvæ underwent a partial metamorphosis. Such masses were laid upon bolting cloth to which they readily attached. The larges masses were hung in small bolting cloth bags in a live box. Whether owing to bad handling or more probably to some inherent difficulty, they did not metamorphose but soon died.

The ease with which larvæ of the same species may be made to fuse together suggests that larvæ of different species might likewise be induced to coalesce. Some experiments along this line could not fail to be of interest.

IV

In the tendency to fuse with the production of a plasmodium, the dissociated cells of sponges resemble the amœbocytes (amœbulæ) of the mycetozoa and Protomyxa. The regenerative power of the plasmodium has an interest both theoretical and economic in itself. But it is the tendency to fuse displayed by the cells that have been forcibly broken apart, which constitutes the fact of most general physiological importance. Discarding for the moment the word "cell" and speaking of the protoplasm of a species as a specific substance, the phenomena may be restated to advantage in the following way.

A mass of sponge protoplasm in the unspecialized state typically exhibits pseudopodial activities at the surface. In

lieu of more precise knowledge it is useful to regard the pseudopodia as structures which explore and learn about the environment. On coming in contact two masses of the same specific protoplasm tend to fuse. This tendency is probably useful (*i. e.*, adaptive) in that the additional safety (from enemies and "accidents") accruing from increase in size of the mass more than compensates for the reduction in number of the individual masses that start to grow (rearing of sponges shows that masses of good size frequently withstand conditions that effectually wipe out the very small masses.) Unlike specific substances (protoplasms of quite different species) do not tend to fuse.

To the many biologists who have found ideas and observations of deep interest in the papers on protoplasmic activities by Professor and Mrs. E. A. Andrews (G. F. Andrews), the statement just made will have a familiar sound. Mrs. Andrews in her essay on The Living Substance as Such and as Organism[9] and her paper on The Spinning Activities of Protoplasm[10] makes, it would appear from subsequent confirmations, a definite advance in our knowledge of the intimate structure of protoplasm. But it is her generalizations, based on singularly acute observations, with respect to the *behavior* of protoplasm, that have especially influenced my own work. The particular generalizations referred to may be so formulated:

1 Protoplasm tends to produce a viscous, pellicular layer with formation of pseudopodial outgrowths over the surface, whether external or internal to the mass, which establishes contact with the environmental medium.

2 Pseudopodia from adjacent masses of the same specific substance tend to fuse. Thus actual connections which can be made and remade, and along which transference of substance takes place, are established between the masses.

That these phenomena are observable in widely separated groups of metazoa has been also shown by Professor Andrews

9 Suppl. to Journ. Morphology, vol. xii, no. 2, 1897.

10 Journ. Morphology, 1897.

in a series of brief studies marked with his well known skill and accuracy of observation and statement. I fully agree with him as to the great importance of the facts.

The general point of view entertained by Mrs. Andrews in her much discussed essay is perhaps not everywhere clear to me. It is manifest however that she consistently subordinates the idea of the individual, whether entire organism or cell, to that of the specific substance of which it is but a more or less detached piece. As far as the cell is concerned this point of view seems to be essentially that of Sachs and Whitman. Mrs. Andrews extends it to the whole organism, and I may say that this way of looking at an animal or plant (or piece of the same) is in my opinion a habit of mind that will justify itself and indeed is doing so today, in that it leads to discoveries concerning the nature of protoplasms as revealed by what they can do.

University of North Carolina,
Chapel Hill, N. C.
October 29, 1907.

FISHES OF NORTH CAROLINA; A REVIEW

BY JOSEPH HYDE PRATT

There has just been issued by the North Carolina Geological and Economic Survey Volume II on The Fishes of North Carolina. This volume has been prepared for the Survey by Dr. H. M. Smith, Deputy U. S. Commissioner of Fisheries. The object of this publication is to give to the people of North Carolina and to others a more accurate knowledge of the abundance, distribution, habits, migrations, spawning, food value, etc., of the fishes in the belief that such knowledge will lead to a fuller realization of the economic importance of the fishery resources to the State. For this reason, it has been the special aim to make the report useful to all the fishing interests of the State. No essential technical considerations have been slighted but the scientific treatment has been adapted to the needs of fishermen and others who have had no opportunity to study ichthyology. It is most desirable that there be created a deeper interest in the welfare of both fishes and fishermen and a better understanding of the conditions and needs of the fishing industry with a view of placing this important branch on a permanent basis and making it yield an increasing revenue to both State and people. This volume will also be of interest to the layman and perhaps of special interest to the angler, as he will be able to make use of the work in the identification of species. As the scientific aspects of the subject have not been neglected, the work will also be found to have a value to icthyologists and zoologists in general.

As a means of identifying any fish that may be taken in any waters of the State, artificial keys have been prepared based on the external characters that commercial fishermen and anglers may readily appreciate and, further, there is a copious index of common names which gives a further clue to all the species whose size makes them objects of capture.

As Dr. Smith states: "Although the fish life of North Carolina is not of a new or distinctive type and bears a rather close resemblance to that of the adjoining States, it does nevertheless have some features of exceptional interest."

On account of the great variation in the topography of the State, the number, length and volume of the rivers and streams, the large, shallow sounds which fringe the coast, the long coast-line, and the wide variation in climatic conditions, there has been developed in North Carolina a fish fauna rich in both species and individuals. Some of the species found in North Carolina are peculiar to this State, while others which were first identified in this State, have later been found elsewhere. Other species exist in much greater greater abundance in this State than in others.

Among the more prominent features of the fish fauna in North Carolina, Dr. Smith mentions the following:

"(a) The abundance of certain anadromous fishes, whose numbers are scarcely surpassed in any other waters, the chief of these being the shad, the alewives, and the striped bass.

"(b) The variety and abundance of suckers, minnows, and sun-fishes in the fresh waters generally, and of darters in the headwaters of the streams on both sides of the Alleghanies.

"(c) The occurence in the sounds and along the outer shores of immense schools of mullet, squeteague, menhaden, blue-fish, croaker, spot, pig-fish, pin-fish and other food fishes.

"(d) The extension to the North Carolina coast of many species which are characteristic of the West Indies or Florida.

"(e) A few species of the Atlantic coast reach their southern limit in North Carolina (such as the cod and tautog) or

FISHES FIRST DESCRIBED FROM NORTH CAROLINA WATERS

PRESENT IDENTIFICATION	ORIGINAL NAME	COMMON NAME	TYPE LOCALITY	DESCRIBER AND YEAR
SILURIDÆ:				
Schilbeodes furiosus*	Noturus furiosus	Mad-tom; Tabby-cat	Neuse River	Jordan & Meek, 1889
CATOSTOMIDÆ:				
Moxostoma papillosum	Ptychostomus papillosus	Red horse; Shiner; White mullet	Catawba and Yadkin rivers	Cope, 1870
Moxostoma collapsum*	Ptychostomus collapsus	Sucking mullet; Small-mouth Red horse	Neuse, Yadkin and Catawba rivers	Cope, 1870
Moxostoma pidiense*	Ptychostomus pidiensis	Sucker	Yadkin River	Cope, 1870
Moxostoma coregonus*	Ptychostomus coregonus	Blue mullet	Catawba and Yadkin rivers	Cope, 1870
Moxostoma album*	Ptychostomus albus	White mullet	Catawba River	Cope, 1870
Moxostoma thalassinum*	Ptychostomus thalassinus	Sucker	Yadkin River	Cope, 1870
Moxostoma robustum*	Ptychostomus robustus	Red horse	Yadkin River	Cope, 1870
Moxostoma crassilabre*	Ptychostomus crassilabris	Mullet; Red horse; Red horse-mullet; Sucker-mullet; Golden mullet; Golden-finned mullet; Horse-fish Red fin; Trout-Sucker	Yadkin River	Cope, 1870
Moxastoma conus*	Ptychostomus conus	Sucker	Yadkin River	Cope, 1870
Moxostoma rupiscartes	Moxostoma rupiscartes	Jumping mullet; Jump-rocks	Catawba River	Jordan & Jenkins, 1889
CYPRINIDÆ:				
Notropis pyrrhomelas	Photogenis pyrrhomelas	Fiery black minnow	Catawba River	Cope, 1870
Notropis niveus	Hybopsis niveus	Shiner; snowy minnow	Catawba River	Cope, 1870
Notropis chlorocephalus	Hybopsis chlorocephalus	Green-headed minnow	Catawba River	Cope, 1870
Notropis brimleyi*	Notropis brimleyi	Brimley's minnow	Cane River	Bean, 1903
Notropis chiliticus*	Hybopsis chiliticus	Red-lipped minnow	Yadkin River	Cope, 1870
Notropis altipinnis*	Alburnellus altipinnis	High-finned minnow	Yadkin River	Cope, 1870
Notropis umbratilis matutinus*	Alburnellus matutinus	Minnow	Neuse River	Cope, 1870
Hybopis labrosus	Ceratichthys labrosus	Thick-lipped minnow	Catawba River	Cope, 1870
Hybopis hysinotus	Ceratichthys hysinotus	High-backed minnow	Catawba River	Cope, 1870
POECILIIDÆ:				
Fundulus rathbuni*	Fundulus rathbuni	Rathburn's killifish	Cape Fear River	Jordan & Meek, 1889
EXOCŒTIDÆ:				
Cypselurus lutkeni*	Exocœtus lutkeni	Flying fish	Beaufort	Jordan & Evermann, 1896
PERCIDÆ:				
Boleosoma maculaticeps*	Boleosoma maculaticeps	Spotted-head darter	Catawba River	Cope, 1870
Etheostoma rufilineatum	Pœcilichthys rufilineatum	Red-lined darter	French Broad River	Cope, 1870
Etheostoma swannanoa*	Etheostoma swannanoa	Swanannoa darter	Swannanoa River	Jordan & Evermann, 1889
Etheostoma vulneratum	Pœcilichthys vulneratus	Red-spotted darter	French Broad River	Cope, 1870
Ioa vitrea	Pœcilichthys vitreus	Glassy darter	Neuse River	Cope, 1870
TRIGLIDÆ:				
Prionotus scitulus	Prionotus scitulus	Slim-flying trad; Flying fish; Flying trad; sea robin	Beaufort	Jordan & Gilbert, 1882
GOBIIDÆ:				
Microgobius holmesi *	Microgobius holmesi	Holm's Goby	Beaufort	Smith, 1907

do not occur in noteworthy numbers further south (such as the white perch and striped bass)."

There have thus far been described from North Carolina waters 345 different species of fish; one species of lancelet; and one of lamprey. This number includes several species that have been introduced into the waters of North Carolina but which have become more or less established. Of these, 209 are marine or brackish water species; 125 are fresh water species; and 11 are anadromous or catadromous species.

Of this number, 29 species of fish were first described from North Carolina waters, of which 18 have as yet been found in no other State. These species are given in the following table together with the name of the species as described in the volume, name under which it was first described, the common name, type, locality, and the person by whom named and the date when the species was established. Those species marked by an asterisk have not been found as yet in any other State.

Under the heading of Systematic Catalogue of North Carolina fishes there is given a full list of all the species of fishes known to inhabit the fresh or salt waters of North Carolina and under each species there is given its technical name and original describer, its popular names, a brief synonomy, a diagnostic description and then a general account of their distribution, abundance, size, habits, food value, economic importance, etc., which have special reference to North Carolina. As an aid to the diagnostic description, a figure is given which shows the parts referred to and the names which designate them (Fig. 1)

Of the three great classes into which fishes and fish-like animals are divided, only the third is important in connection with the fishes of North Carolina, as the first two classes contain only one representative each. These classes are as follows:

KEY TO THE CLASSES OF FISHES AND FISH-LIKE ANIMALS

i. Animals with cartilaginous skeleton and without brain or skull; fins rudimentary and only on median line of body; mouth a slit surrounded by bristles; heart a tubular vessel without separate chambers; blood colorless; gillslits numerous, the respiratory cavity opening into the abdomen; inspired water discharged through a special abdominal pore.

LEPTOCARDII (lancelets).

ii. Animals with cartilaginous or bony skeleton; skull and brain present; heart developed as a cavity with at least two chambers; blood red.

a. Eel-shaped; skeleton cartilaginous; skull imperfect; mouth circular, suctorial; no jaws or paired fins; a single median nostril; gills pouch-shaped and numerous; skin naked; alimentary canal straight, without cœca; pancreas and spleen absent.

MARSIPOBRANCHII (lampreys, etc.)

aa. Skull well-developed; jaws distinct; fins usually highly-developed, some of them paired; skin usually scaly; nostrils at least two, not median; gill-openings a single slit on each side in most fishes (numerous in a few families); alimentary canal more or less convoluted; pancreas and spleen present.

PISCES (fishes).

Of the third class, Pisces, the North Carolina representatives fall into two easily recognized groups or sub-classes: (1) the Shark, Skates and Rays and (2) the True Fishes, which are distinguished anatomically as follows:

i. Skeleton cartilaginous; skull without sutures and without membranous bones; gill openings numerous (5 to 7) and slit like, the gills attached to the skin; tail heterocercal; skin tough, naked or covered with small rough scales, spines, or tubercles; air-bladder absent; jaws separable from skull; species viviparous or ovoviviparous, the eggs large and few in number; embryo with deciduous external gills.

SELACHII or ELASMOBRANCHII (sharks, skates, rays, etc.)

Fig. 1. CUT OF YELLOW PERCH SHOWING PARTS USUALLY REFERRED TO IN DESCRIPTIONS

1. Depth
2. Head
3. Eye
4. Snout
5. Premaxillary
6. Maxillary
7. Lower Jaw
8. Opercle
9. Suboperele
10. Preoperele and cheek
11. Branchiostegals
12. Lateral line.
13. Length of caudal peduncle
14. Depth of caudal peduncle
15. Vent
16. Spinous dorsal fin
17. Soft dorsal fin
18. Anal fin
19. Caudal fin
20. Pectoral fin
21. Ventral fin

ii. Skeleton bony in all but a few families; skull with sutures and membranous bones (opercula, etc.); gill-openings a single slit on each side, the gills attached to bony arches; tail heterocercal or homocercal; body usually covered with numerous flat scales; air-bladder present or absent; jaws not distinct from the skull; species oviparous (exceptionally viviparous), the ova small and numerous.

TELEOSTOMI (true fishes).

In the first class are included 9 species of shark and 11 species of rays. In the second class (true fishes) there are 325 species. The 12 largest families included in these are as follows:

Cat-fishes	12	species	in	4	genera.
Suckers	18	"	"	5	"
Minnows	36	"	"	9	"
Killi-fishes	9	"	"	5	"
Mackerels	8	"	"	6	"
Carangids	17	"	"	8	"
Sun-fishes	17	"	"	10	"
Perches	24	"	"	12	"
Sea basses	11	"	"	7	"
Sparids	7	"	"	6	"
Drums	14	"	"	10	"
Flounders	11	"	"	7	"

The fisheries of North Carolina are of considerable economic importance to the State, approximating in value $2,000,000 per year, the catch being utilized largely for food purposes. Of the 347 species listed, there are about 90 that are of present commercial value, most of which are used for food. In the following table there is given a list of those that are used for this purpose. In this table there is given the common as well as the scientific name.

FISHES USED FOR FOOD IN NORTH CAROLINA.

Sturgeon (*Acipenser oxyrhynchus*).
Suckers (Family Catostomidae. North Carolina has more species of suckers than any other State; 8 species used as food).
Red Horse (*Moxostoma Crassilabre*).
Choly; shiner (*Hybognathus Nuchalis*).
Horned dace (*Semotilus Atromaculatus*).
Roach; shiner (*Notemigonus Crysoleucas*).
Carp (*Cyprinus Carpio*).
Eel, fresh-water eel (*Anguilla Chrisypa*).
Sea Herring (*Clupda Harengus Linnaeus*).
Hickory Shad (*Pomolobus Mediocris*).
Branch Herring, Alewife (*Pomolobus Pseudoharengus*).
Glut Herring, Shoal Herring (*Pomolobus Aestivalis*).
Shad (*Alosa Sapidissima*).
Menhaden (*Brevoortia Tyrannus*).
Brook Trout; Mountain Trout (*Salvelinus Fontinalis*).
Rainbow Trout; California Trout (*Salmo Irideus*).
Pike; Pickerel (*Esox Americanus* and *Esox Reticulatus*).
Mullets (*Mugil Cephalus* and *Mugil Curema*).
Bonito (*Sarda Sarda*) variety of mackerel.
Spanish Mackerel (*Scomberomorus Maculatus*).
Cero (*Scomberomorus Regalis* and *Cavalla*).
Sword-fish (*Xiphias Gladius*).
Pompano; Sun-fish (*Trachinotus Carolinus*).
Blue-fish (*Pomatomus Saltatrix*).
Cabio; Crab-eater (*Rachycentron Canadus*).
Star, Harvest-fish (*Peprilus Alepidotus*).
Butter-fish (*Poronotus Tricanthus*).
Calico Bass; Speckled Perch (*Pomoxis Sparoides*).
Flier (*Centrarcus Macropterus*).
Rock Bass (*Ambloplites Rupestris*).
Goggle-eyes; Warmouth (*Chaenobryttus Gulosus*).
Long-eared Sun-fish; Red-belly; Robin (*Lepomis Auritus*).
Blud Joe; Blue-gills; Blue Sun-fish (*Lepomis Incisor*).
Holbrook's Sun-fish (*Lepomis Holbrooki*).

Sand Perch; Pumpkin-seed (*Lepomis Gibbrosus*).
Black Bass; small mouthed (*Micropterus Dolomien*).
Black Bass, large mouthed (*Micropterus Salmoides*).
Pike Perch; Wall-eyed Pike (*Stizostedion Vitreum*).
Yellow Perch; Red-fin (*Perca Flavescens*).
Striped Bass; Rock-fish (*Roccus Lineatus*).
White Perch (*Marone Americana*).
Black-fish; Sea Bass (*Centropristes Striatus*).
Pig-fish; Hog-fish (*Orthopristis Chrysopterus*).
Snapper; Grunt (*Hæmulon Plumieri*).
Scup; Pin-fish (*Stenotomus Chrysops*).
Sailsois choice; Robin (*Lagodon Rhomboides*).
Sheepshead (*Archosargus Probatocephalus*).
Squeteague; Weak-fish; Sea Trout (*Cynoscion Regalis*).
Spotted Squeteague; spotted Weak-fish (*Cynoscion Nebulosus*).
Yellow Tail; Sand Perch; Perch (*Bairdiella Chrysura.*)
Spot (*Leiostomus Xanthurus*).
Croaker (*Micropogon Undulatus*).
Red Drum; Red-fish (*Sciaenops Ocellatus*).
King-fish; Sea Mullet; Carolina Whiting (*Menticirrhus Americanus*).
Sea Mullet; King-fish (*Menticirrhus Saxatilis*).
Surf Whiting (*Menticirrhus Littoralis*).
Black Drum (*Pogonias Cromis*).
Oyster-fish; Tautog (*Tautoga Onitis*).
Porgee, Spade-fish (*Chaetodipterus Faber*).
Cod (*Gadus Callarias*).
Flounder; Summer Flounder; Plaice (*Paralichthys Dentatus*).
Flounder, Southern, (*Paralichthys Lethostigmus*).
Flounder (*Paralichthys Albiguttus*).

All the fishes mentioned in this list are found to a greater or less extent in the markets, but only a few of them are of any large economic value to the State. Of the migratory fishes, the most conspicuous and the ones of most value are

the shad, alewives, hickory shad, striped bass, white perch, eel and sturgeon. Of the salt water fishes would be included the mullets, squeteagues, Spanish mackerel, croaker, spot and menhaden. The principal fresh water fish is the large-mouthed black bass. The spotted squeteague, pig fish, hickory shad and black bass are taken in larger quantities in North Carolina than in any other State.

On account, however, of over-fishing and non-enforcement of present laws relating to the fisheries, the industries are deteriorating and in some instances quite rapidly. Unless the State will provide prompt and adequate protection to the shad, alewives, striped bass and other species which are beginning to show a decrease in abundance, they will soon share the same fate as the sturgeon.

There is no reason why the fisheries of North Carolina should not be maintained for an indefinite period and even be very greatly improved; and to this end the session of the Legislature of 1907 created a Fsh Commission, but with very limited powers. It is to be hoped that at the session of 1909 the powers of the Fish Commission will be increased so that it will be in a position to prevent the causes of decline in these industries and be able to utilize all resources for building up and increasing the abundance of fish.

The Geological and Economic Survey, in cooperation with the United States Bureau of Fisheries, has carried on certain lines of work in regard to the protection and reproduction of the fishes of North Carolina, conducted through the Biological Laboratory at Beaufort, the hatchery at Edenton and the temporary hatching stations near Weldon. A number of fish have been introduced into the waters of North Carolina, some of which have become widely distributed and firmly established, such as the rainbow or California trout and the carp.

Large numbers of native fishes from outside hatcheries have been planted in the State, among these being the brook trout, large-mouthed and small-mouthed black basses, various sun-fishes, and several kinds of cat fishes.

REVIEWS

Van Nostrand's Chemical Annual, 1907. First Year of Issue. Edited by John C. Olsen, A. M., Ph. D. New York, D. Van Nostrand Co. x – 496 pp. The "Chemiker Kalendar" has long been a most useful publication but American chemists have desired a similar publication in English. In the new Annual Professor Olsen has improved upon the German model and produced an extremely satisfactory reference work. It consists exclusively of tables of physical and chemical data and lists of publications. The physical constants of inorganic and organic compounds are given in two tables, comprising nearly one half of the book. It is a pleasure to find frequently definite values for solubilities. The "Review of Chemical Literature" consists of a classified list of the more important articles published in the Journals and also a classified list of books, the time covered being from Jan. 1, 1905 to June 1, 1906. It is cause for congratulation that Professor Olsen undertook the editorship of a book which is so indespensible to the chemist. The execution of the mechanical part is excellent. A. S. W.

Solubilities of Inorganic and Organic Substances. A hand-book of the most reliable quantitative solubility determinations. Recalculated and complied by Atherton Seidell. 8vo X - 367 pp. D. Van Nostrand Company. New York, 1907. The only dictionary of chemical solubilities has been Comey's which was published in 1894. Although it is a book of great value there are several defects which detract from its usefulness. It contains no organic substances but we find instead a great variety of rare inorganic double salts. Too many unreliable determinations are incorporated and the arrangement is not consistent throughout so that it is fre-

quently troublesome to locate a compound. Seidell has introduced a large number of important organic substances, the selection of inorganic compounds is more satisfactory, the arrangement is logical throughout, and the determinations are more reliable. Greater reliability was arrived at with much labor by recalculating the various determinations to a common basis and drawing curves through the points plotted. Selections were then made after comparing the curves and studying the methods of determination. An index adds to the value of the book. Every chemist should have access to this thoroughly satisfactory dictionary, in fact it should be in every working scientific library. A. S. W.